Hydraulic Characterization of the Kabatini Aquifer, Upper Lake Nakuru Basin, Kenya rift, Using Geophysical and Pumping Test Data

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Abstract:

The Kabatini well field, herein referred to as the study area, is located in the upper Nakuru basin, about 160 km North West of the city of Nairobi, on the floor of the Kenya Rift Valley (KRV). The geology of the area comprises mainly of volcanic rocks (lavas and pyroclastics) of Tertiary-Quartenary age, which are overlain by recent sediments. The drainage is characterized by very poor surface runoff due, high porosity, permeability and loose structure of the volcaniclastic, highly pumiceous and poorly sorted rocks covering the older consolidated lava flows. Lithological logs analyses show aquifer thickness variation up to about 86 meters, with aquifer materials consisting commonly of volcanic sediments, weathered/fissured trachytes, pumice and pyroclastics. This means that groundwater movement and retention is very variable and thus requires evolved schemes for improved characterization. In order to assess groundwater potential in the area, and /or to evaluate the impact of pumpage on its groundwater regime, it is vital to know adequately the aquifer hydraulic parameters. Such parameters are chiefly natural recharge, hydraulic conductivity, transmisivity and storativity. These parameters are also vital for the rational management of groundwater through the use of groundwater flow model. A geophysical study using the Vertical Electrical Soundings (VES) techniques has been used to investigate the sub-surface distribution of the hydro-physical characteristics in the study area. Geoelectrical sounding data have been interpreted by computer programs EarthImager ID and GeWin. This initial starter model has then been adjusted based on prior knowledge of subsurface lithology to obtain the final layer parameters. The resistivities for most of the aquifer zones are low depending on their grain packing, size, saturation and mineralogy (Bernabe and Revil; 1995). Conventional methods of measuring these parameters would require drilling boreholes which provides accurate information at every point of depth. However, collection of such detailed information was not viable economically for purposes of this study. However, borehole lithological logs, geological reports, topographical maps, hydrogeological and hydrological information were used to develop the conceptual model of the area. Averaged values of hydraulic parameters were estimated through the use of archived test pumping d Wong et al (1984).A field scale linear correlation was found to exist between natural logarithm of Transmisivity and natural logarithm of Formation Resistivity Factor of the groundwater flow domain. The algorithm determines the characteristics of the local (site dependent) transmissivity-formation factor relationship and utilizes this auxiliary information for geostatistical transmissivity field variability. An attempt has been made to find general functional relationships between hydraulic parameters and geoelectric resistivity of the aquifer. It is found that for sufficient pore volumes and fractures in rocks of the study area, porosity and transmissivity are

best defined as power law functions of aquifer resistivity. The empirical relations between aquifer parameters and resistivity are established for transforming resistivity distribution into porosity (permeability), transmissivity and hydraulic conductivity of the aquifer. This characterization scheme was feasible as both electrical potential and groundwater channels through interconnected pore-spaces in the groundwater flow domain. Such interconnectedness of the pore volume (representing porosity) as may be described from the hydraulic conductivity and electrical conductivity of the pore fluid determine the flow. Hydraulic parameters are therefore a measure of the interconnection of pore volumes (porosity). The geo-electrically resolved hydraulic parameters and processes are important for sustainable groundwater resource management through groundwater modelling. The information thus obtained from pumping test and resistivity data for the study area can be used for optimal use and assessment of water resources.